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Duration of Organizational Decision Processes in Organizations in View of Simulation Calculations

Abstract

This article deals with the time course of decision processes in organizations. The interaction of important determinants of collective decision-making is analyzed using a simulation model. The results show that the course of decisions is largely determined by structural parameters, which can only be influenced to a limited extent, thus, paradoxically, escaping the direct effects of willful decision-making. The presentation of results is supplemented by considerations regarding the effectiveness of the simulation method.

Keywords: simulation, organizational decision making, decision processes, decision time, decision theory, attention, problem definition, implementation, problem solving (JEL: C63, D70, D78, D91, M00, M10)

Problem

Decision processes in organizations often take tortuous routes. At least, this applies if decisions concern complex issues, which are connected with conflicting interests. Solutions for such decision problems are not simply "found", in many cases they must rather be laboriously "worked out". Surprises, mistakes, failures, learning experiences, changes of direction, instability in motivation are thus unavoidable. Moreover, decisions in organizations are collective actions, i.e. you often have to deal with contradictory objectives, incompatible convictions and ideas, with alliances, intrigues, negotiations, conformism, profile-raising and indifference. Therefore, there are many reasons why decision processes do not evolve as it is recommended by textbooks and confirmed by management consultants. And this is naturally reflected in the time needed to solve decision problems. This article addresses the question of how the interaction of key decision determinants affects decision time. The simulation method is used for this purpose. Simulations are powerful methods to generate scientific knowledge. They are particularly suitable for the analysis of complex relationships and thus the examination of the course of collective decision processes.

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The Time Aspect of Complex Decisions

The time aspect of decision-making in organizations is often addressed, but it is rarely examined thoroughly, in empirical decision research.[1] An exception is the empirical study by Mintzberg, Raisinghani and Théorêt (1976). The authors emphasize the significance of "dynamic factors" i.e. factors which have a considerable impact on the course of decision processes and the time they take. Mintzberg, Raisinghani and Théorêt describe six of these factors in detail: interrupts, scheduling delays, feedback delays, timing delays and speedups, comprehension cycles and failure recycles. They formulate different hypotheses. The following statement is cited as an example: "… decision processes without interrupts averaged 1.3 years, while those with delaying interrupts averaged 3.6 years. This is presumably related to the earlier finding that duration and political activity are related, since delaying interrupts and political activity are often found together. Hence we hypothesize that interrupts of a political nature significantly delay strategy decision processes." (Mintzberg/Raisinghani/Théorêt 1976, 264). Hickson, Butler, Cray, Mallory and Wilson (1986) identified three modes or types of decision-making in their analysis of 150 strategically important decision processes: "constricted", "fluid", and "vortex sporadic". According to them, vortex sporadic decision processes are especially time-consuming because they are very complex and politicized. In their analyses of the decision time, Baum and Wally (1994) mainly concentrate on the characteristics of decision-makers, on capabilities, risk tolerance, willingness to engage and the preferred decision-making style (Baum/Wally 1994, Wally/Baum 2003). Furthermore, they examine the effects of organizational structure characteristics (e.g. centralization) and different environmental factors (e.g. the environmental dynamics[2]). McCall and Kaplan (1985) deal with a number of other factors, which are plausibly assumed to influence decision time, as for example external pressure, deadlines, crises, accidents, failure, deterioration, outside pressure (McCall/Kaplan 1985, 46 ff.). Langley, Mintzberg, Pitcher, Posada und Saint-Macary (1995) also point out that problems seldom come alone but most often are linked with many other problems, a fact, which will not be without effect on the decision time.

Besides the aforementioned factors, there are many other factors, which affect the duration of decision activities. Examples are the number of participants, management structure, needs for legitimization, and experience with the decision object. Many factors concern the structural conditions of the environment (e.g. its dynamics), others result from requirements of the social environment (e.g. accountability)

1 For the origins and development of organizational decision research, see Simon 1945, Thompson/Tuden 1959, Kirsch 1971, Janis 1989, March 1994, Hodgkinson/Starbuck 2008, Nutt/Wilson 2010, Martin 2019a.

2 The studies by Eisenhardt 1989 and Judge/Miller 1991 are also focused on the environmental dynamics and their interaction with decision speed and success. The empirical significance of situational variables, age and experience of the executive board for decision speed, was examined by Forbes 2005.

and still other factors are in the narrower sense decision theory variables, i.e. variables, which directly refer to the decision behavior of the actors (e.g. time preferences, perception of problem complexity, aspiration level).

The model presented in the following deals with some "characteristic features" of decision processes, i.e. with variables which can be considered as basic categories, in other words, variables without which it is hardly possible to describe the course of decision processes in a consistent way. The focus is on the elementary activities of every decision process and the challenges connected with them. Thereby, it is necessary to take account of the available problem-solving capabilities and structural obstacles, which may obstruct the management of decision tasks. The processing capacities and problem load are also of elementary importance (for further description, see Section 2).

Simulation as Method of Analysis

The model presented in this article focuses on decision tasks, i.e. it is a task-oriented model.[3] Of course, models with a different layout are also feasible. The decisive factor for the construction of a model is the explanation purpose. The probably best-known simulation model of organizational research, for example, the so-called "garbage can" model by Cohen, March and Olsen[4] is designed to show that problems are often overlooked, problems often wander around in organizations without being solved and problem solutions are rare events, which only occur under certain favorable conditions. The complicated and hardly satisfactory decision processes mainly result from the fact that the elements, which are required for problem solutions (namely problems, solutions, actors and decision opportunities) flow largely independently from each other through an organization. These flows are linked by decision structures (access for problems and actors to decision opportunities) and the solution energy of participants in decision processes. The garbage can model is also mainly concerned with task-related aspects. Its emphasis is on the difficulties in harmonizing the actors, resources and processes necessary for problem solution.

A major criticism of the garbage can model is that the theoretical statements and verbal explanations by the authors partly deviate from the actual model implementation of the simulation program. Such discrepancies cannot always be completely avoided. There are parallels to this in the operationalization problem posed in empirical research. Another criticism is that the literature surrounding the garbage can model does not seriously address the mechanisms of action formulated in the mod-

3 Which, irrespective of this, can also integrate psychological and socio-structural variables (see below).

4 Cohen/March/Olsen 1972, Cohen/March/Olsen 2012. For the theoretical background, see March/Olsen 1976. For criticism and for further developments, see also Levitt/Nass 1989, Masuch/LaPotin 1989, Troitzsch 2008, Lomi/Harrison 2010.

el. The garbage can model often only serves metaphorically as a proof of organizational disorder.

The criticism by Bendor, Moe and Shotts (2001) is particularly fierce. They complain that the garbage can model does not really answer the question how participants make decisions. They expect the authors to make progress in the development of the decision theory whereby the simulation program itself should be of minor interest. According to them, the key issue must be the content of the theory, which has to be formulated verbally. However, a simulation program in fact cannot be considered a formulation of a theory, i.e. it cannot be the version of a theory translated into calculation steps, a depiction of the abstract ideas of the theory. Nevertheless, simulations should contribute to theoretical progress. And, indeed they can, however, not by regarding them as a target but as a means of theory development.[5] Simulations serve well in describing the structure of mechanisms and reconstructing how particular conditions and behavioral patterns develop from the interaction of model variables. In this respect, model development has both a critical and constructive function. For example, it can be examined whether the behavior results obtained in the simulation calculations are compatible with common ideas, it can help in detecting logical errors in the theoretical argumentation and it can show, which effects are overestimated or underestimated. The simulation method is constructive to the extent that it provides indications of faulty assumptions and unclear model specifications and can thus give reason to correct the underlying theoretical assumptions of a model. Furthermore, the development of a simulation program compels you to express yourself accurately, thus counteracting the tendency to give room to vague excuses in view of inconsistent results.

The strength of simulations becomes apparent especially when dealing with complex relationships, i.e. in the analysis of the conclusions resulting from the assumptions of the model. The derivation of the logical consequences of the model statements does not result in an increase in the content of the model because all derivable statements are already included in the premises. Nevertheless, a model analysis normally provides "new" information because the conclusions of the model statements often cannot be easily assessed. Thus, the authors of the garbage can model, for example, conclude that important problems are solved less frequently than unimportant problems, a conclusion that does not immediately come to mind – and which contradicts common understanding. The simulation model presented in this article is intended to show that only a few parameters and very simple mechanisms are sufficient to generate a variety of course types of decision processes and that this variety nonetheless follows a recognizable pattern.

5 For the logics and methodology of simulations, see Bunge 1973, 114 ff., Lindenberg 1977, Braten 1982, Troitzsch 1990, Gilbert 1996, Weber 2004.

Model Description

The model presented in this article deals with the course of organizational decision processes. Like the garbage can model, it is not concerned with the further development of the theory of individual decisions. It rather examines the creation of the time patterns formed in a decision process, it does not consider the actual behavior of the actors but specific decision-making processes. Hence, the analysis is performed on a behavioral level above the individual behavior.[6]

The simulation model is based on a manageable number of basic statements. The constructs used in these statements encompass a set of carefully selected factors. For instance, the objectives of the actors, which play a major role in each decision, are not explicitly considered in the model. However, they are implicitly included in the *priorities*, which are a key element of the simulation model. Other important variables are urgency and time pressure. They too are manifested in the priorities, and by means of this variable only implicitly integrated in the model. Likewise, the model variable "*capabilities*" is not about the intellectual capabilities of the actors but the problem-solving resources available to the decision system, i.e. it includes also the financial resources, which allow investment in research, development, information activities and consulting. The model variable "*obstacles*" encompasses a number of different influencing factors which are highly important for the decision process but which cannot be integrated individually in the model without making it too complex.

Finally, the variable "*addressing the problem*" is a variable, which plays a key role in the simulation model presented in this article. James March intensively discusses the essential importance of *addressing the problem* for decision making in organizations (March 1964, 24). However, he uses the term "attention" to describe this issue. I do not want to follow this approach because, firstly, the term "attention" is already used in this article as the designation for the (often non-specific) perception of a problem. Secondly, this term is often associated with the more or less specific perception of a *problem*, whereas our article is about addressing any individual *decision activity*. Our model defines the term "addressing the problem" as the probability of a problem being tackled. As already mentioned, this variable does not refer to the problems that enter the decision system but to all individual activities that have to be carried out during a decision process. Our model analyzes four basic activities, which are indispensable in every decision process, i.e. which must always be performed (although not necessarily always with great intensity): identification of the problem, definition of the problem, processing of the problem, and implementation of the solution found. The time pattern to be examined does not only refer to the

6 Of course, to understand and assess the model, one has to consider some essential background assumptions about individual decision-making. However, the analysis of the statements, which follow from such assumptions, is not part of the model.

overall length of the decision process but also to the respective duration and thus the distribution of the time needed for the specified decision activities.

Model Structure

Figure 1 shows the structure of the simulation model. The model describes the path each problem takes through the decision system. The status of the problems achieved is recorded in every period. It is analyzed whether the problem has already been noticed, whether it has been identified and defined, whether a solution has been worked out and if the solution found has already been implemented.

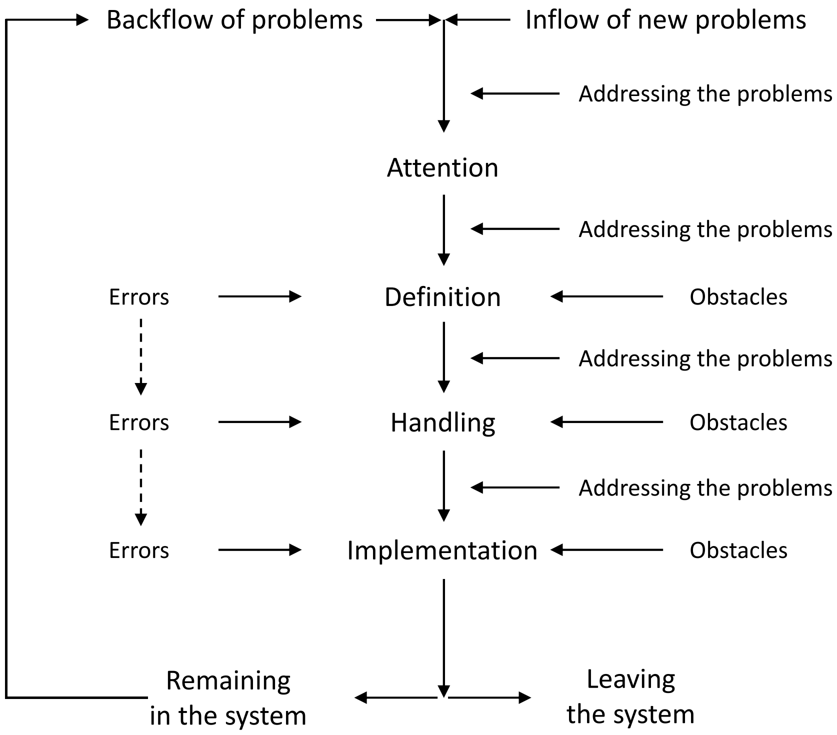


Figure 1: Model structure

Thus, the objects of the analysis are the core activities required for each decision process. These are, however, exposed to impairments. Essentially, there are three "problems of problem processing". As previously mentioned, the first problem is addressing the problem. Since problem-processing capacities are limited, it is not possible to give the same attention to all problems. Therefore, the processing of a problem is often deferred, sometimes consciously and deliberately, however, sometimes of necessity and unnoticed as a result of other demands. The second problem results from the numerous obstacles, which may obstruct and retard problem processing. The third problem arises from the errors made. Errors are inevitable and, like the addressing and obstacle problems, concern the definition, problem-solving and implementation phases.[7] Furthermore, they continue. A wrong definition cannot lead to a proper solution and a wrong solution will not result in satisfactory success, i.e. the problem will not really be solved or eliminated. Problems that are solved leave the decision system. Problems remaining after completion of all partial activities compete with the flow of new incoming problems for attention and must be readdressed.

Overview of Variables

Table 1 lists the variables used in our simulation model. The "independent variables" are the parameters of the model. The variation of these parameters is within the specified value ranges.

The simulation model runs over 800 periods. Since 4 new problems per period flow into the decision system in the standard version, the overall analysis encompasses 3,200 problems. However, only 100 periods are considered in detail for each simulation run (starting with period 21 and ending with period 120), thus amounting to 400 problems. The analysis starts only after 20 periods because the initial situations where only very few problems are in the system create special conditions, which differ from the normal situation of a busy system and would thus distort the statistical picture if they were considered. The simulation continues after period 120 up to period 800. This is necessary because the "fate" of all problems arising in the 100 periods, i.e. the further course of the problems occurring in the last periods (e.g. period 120) for the first time, must also be captured. In adverse situations, the processing time of individual problems may become extremely high. For this reason, the analysis period must be considerably extended to avoid "missing" cases.

A fundamental element for a decision system is its problem-solving capacity as it determines whether the problems arising over time can be managed at all. The available *capacity* and the *extent of problem load* are often firmly rooted and difficult to change. In comparison to this, *problem-solving capabilities* are often easier to change. They determine how many "errors" are normally produced by the decision system. Operationalization is about the probability that decision activities do not really contribute to solving a problem so that the decision process has to start all over again.

7 There is no such thing as "wrong attention". Only the problem definition phase will show whether an identified problem is not a problem. Furthermore, it makes little sense to assume specific obstacles for the attention phase. Problems arise in this respect only from a general "non-responsiveness", which then however affects all phases and is not given particular emphasis in our model.

Independent Variables	Values	Explanation
Periods	100/800	Number of periods considered
Input set	2... 6	Number of new problems per period
Capacity	12... 100	Number of problems that can be processed per period
Attention (PA)	0.0... 1.0	Probability that the problem is noticed
Selection factor(PA)	0.2	Weighting factor for the selection coefficient "Attention"
Significance	0.0... 1.0	Increase factor of the priority weight if problems are not dealt with
Selection (PD)	0.0... 0.9	Probability that no problem definition is carried out
Selection (PH)	0.0... 0.9	Probability that no problem handling is carried out
Selection (PU)	0,0... 0.9	Probability that no decision is implemented
Capabilities	0.7... 0.8	Probability that the correct problem definition is carried out
Interest	0.0... 0.9	Probability that problem processing is deferred due to great conflicts of interest
Routine	0.0... 0.9	Probability that problem processing is deferred due to unsuitable decision procedures
Difficulty	0.0... 0.9	Probability that problem processing is deferred because of technical organizational difficulties being too great
Characteristics of the Problems		
p (i)	1 ... 4800	Number of the problem
Priority weight	0 to 1	Uniformly distributed inflow of significant and insignificant problems
Time weight	0 ... 800	Weighting factor in priority setting
Priority	1... n	Rank for addressing the problem
Attention	0; 1	Attention status
Definition	0; 1	Definition status
Handling	0; 1	Handling status
Implementation	0; 1	Implementation status
Forgetting	0... 100	Problem outflow because of permanent non-processing
Problem occurrence	1 ... 800	Time of problem occurrence
Attention, $t_{a\omega}$	1 ... 800	Time of attention (last value)
Definition, $t_{d\omega}$	1 ... 800	Time of definition (last value)
Handling, $t_{h\omega}$	1 ... 800	Time of handling (last value)
Implementation, $t_{i\omega}$	1 ... 800	Time of definition (last value)
Processing rounds	1 ... 800	Number of recurring processing rounds
Attention, $t_{a\alpha}$	1 ... 800	Time of attention (first value)
Definition, $t_{d\alpha}$	1 ... 800	Time of definition (first value)
Handling, $t_{h\alpha}$	1 ... 800	Time of handling (first value)
Implementation, $t_{i\alpha}$	1 ... 800	Time of implementation (last value)

Length of the decision process		
Overall duration	3 ... 800	Time from problem occurrence to the ultimate implementation
Attention phase	0 ... 800	Time from problem occurrence to the last attention
Definition phase	1 ... 800	Time from the first attention to the last valid definition
Handling phase	1 ... 800	Time from the first definition to the ultimate handling
Length of the implementation phase	1 ... 800	Time from the first handling to the ultimate implementation
Activity periods	1 ... 800	Time from a particular activity to another activity
Processing cycles	1 ... 800	Number of new additions of problems
Course patterns		
Course types	A, B, C, D ...	Cluster of phase lengths
Continuity	K, L, M, N...	Continuity of phase courses
Problem-solving level		
Long-term problems	0 ... 100 %	Cases with an overall duration 21... 100 periods
Activity level	0 ... 100 %	Frequency of the decision activities

Table 1: Variables of the model

The other impairments of the decision process are also conceived as the probability that an actual problem is tackled ("*addressing the problem*") and as the probability that *obstacles* obstruct problem processing so that it cannot be continued at the time under consideration. In the model, this means that the problem is not further considered whenever the event determined by the probability occurs.

Another variable group refers to central problem characteristics and their changes. The question is whether a certain problem is given attention at all, whether it has already been defined, whether solutions are sought and implemented. *It is also recorded at what time these activities take place*. These data can be used to determine the duration of the decision process and its sub-phases. *Setting priorities* is of central importance because, in a given time frame, it is only possible to deal with as many problems as the capacities allow. Hence, a selection must be made among the problems to be dealt with first. When assigning priorities it is assumed that problems are uniformly distributed over the spectrum of their significance, i.e. problems of low significance are as frequent as problems of great significance. Since the significance of problems changes with the duration of problem processing, which has or has not been carried out (as an expression of its importance and urgency), priorities must be reset in practically every period. It must also be taken into consideration that the *problem inflow* (the input set) shows fluctuations and is increased by the backflow of problems that could not be solved.

The *length of decision phases* serves as a result variable (as "dependent variable"). Based on this, different time patterns are considered (see Martin 2019b for details). The *problem-solving level* is evaluated by using two ratios, which are also concerned with the time aspects of decision activities. It should be noted, that the solution of a problem may take a long time but every problem will eventually be solved. At least, that is how it is conceived in this simulation model. However, the time needed to successfully complete a decision process varies considerably. The ratios for identifying *long-term problems* designate the percentages of cases where more than 20 or more than 40 or more than 100 periods pass until a solution is found.

Analyses

What course does a decision process take? To be able to answer this question, it is necessary to have a closer look at the fate of each individual decision problem, which is determined by the relevant particular circumstances. Therefore, the simulation must be about combining the values of the model parameters, which are used to map these special conditions, and calculating the resulting decision courses. Since the parameters are continuous variables, there is an infinite number of possible combinations. Of course, this cannot be mapped. It is therefore important to select and combine a number of discrete values. However, there are also limitations in size. The model encompasses 8 independent variables ("parameters"). If 7 values are considered for each of the 8 variables, there are 7^8 = 5,764,801 possible combinations. The model simulates 800 periods with 4 new problems entering the decision system per period so that 7^8 x 800 x 4 = 18,447,363,200 individual cases are produced for the above-mentioned interpretation of the model. Since random influences are simulated in the model, the procedure for generating these individual cases would have to be repeated several times because, strictly speaking, this is the only way to assess and limit the effect of random influences. Due to the complexity of the model, the calculating time is very high even for one single simulation run. Thus, the full combination procedure is too much for standard computers. There are different possibilities to deal with this problem. You can draw random samples from the possible parameter constellations and carry out the simulation calculations on this basis. You can consider only a few but powerful characteristics. Thirdly, you can limit the analysis to a selected, empirically significant standard constellation and, based on this, vary the model parameters. Each method has its specific pros and cons. The results mentioned in the following are based on the latter procedure (for more details on the application of the two other procedures, see Martin 2019b).

Results

Problem Flow and Problem-Solving Capacity

There is a quasi-logical relation between the number of problems solved over time, the problem flow and the problem-solving capacity. The greater the flow of incoming problems, the greater the problem-solving capacity must be because otherwise the unsolved problems would accumulate which would sooner or later lead to a paralysis of action. In our model, a problem must run through a minimum of 3 periods until it is solved.[8] For example, if 4 new problems enter the decision system per period, there must be a problem-solving capacity of at least 12 problems per period (number of incoming problems per period multiplied by three) in order that the problem outflow corresponds to the problem inflow. However, this simple multiplication rule only applies to the *ideal situation*, i.e. if everything "goes well", if every problem is tackled, if there are no obstacles in problem processing and if no errors are made. Then the above-mentioned capacity of 12 problems per period is sufficient to eliminate and solve each problem after three periods. For example, if the problem-solving capacity is only 8 problems per period, the decision process will be severely impaired despite the aforementioned ideal conditions. In this case, from problem occurrence to problem solution, on average, there are more than 40 periods and 40 % of the problems need more than 50 periods until they are solved.

Generally, the above-mentioned *ideal situation* is not very realistic because errors are made, problems are not addressed, and problem processing and implementation has to deal with obstacles. If you want to ensure that the decision system remains in balance even under adverse conditions for action, the problem-solving capacity must often be much higher than for the ideal situation. This means that you will quickly face the capacity problem if a decision process does not run smoothly. If every fifth problem is not addressed consistently although a solution has already been worked out (p=0.2), the number of problems that have not been solved within 100 periods will increase from an average of 12 to 40 problems. If the relative share of solutions that are not implemented in time doubles or triples (p=0.4 or p=0.6), the number of unsolved problems will increase even further. In order to restore balance, the problem-solving capacity must be expanded. For the first two cases (p=0.2 or p=0.4), a fairly moderate increase in capacity (from 12 to 15 problems/period) is sufficient, for the latter case (p=0.6), however, a much greater expansion of the problem-solving capacity is required. Strictly speaking, the above-mentioned increase to 15 problems/period will achieve nothing; the number of cumulative problems will even continue to increase in this case. A fairly stable balance will only be established if the capacity is expanded to 19 problems/period.

8 Once a problem has been identified, it must be defined, then a solution must be worked out and finally the solution must be implemented. Each of these problem solving or decision phases requires one period in our model. The "attention phase" plausibly has no temporal extent.

Parameter Constellations

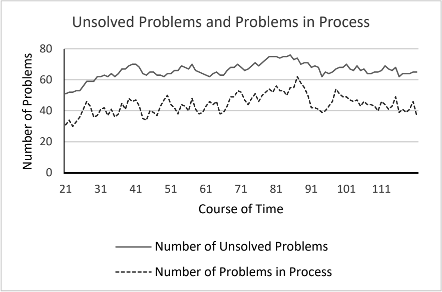
To check the individual parameter effects, three basic configurations are considered. The first configuration is the ideal constellation, i.e. when the problem is fully addressed without obstacles or errors. The second constellation assumes that in 20 % of cases the problem at hand is not processed in each of the decision phases, problem definition, problem handling and solution implementation. Furthermore, only 80 % of the problems arising are identified and in 20 % of cases, there are special obstacles, both due to conflicts of interest and inefficient decision procedures and technical organizational difficulties. In this second standard constellation, the problem-solving capacity is p=0.75, i.e. in 25 % of cases, there is no appropriate ("right") problem processing in the individual phases, if they are addressed at all. In the third constellation, the capability parameter is also p=0.75, the other values are not p=0.2 as in Standard Constellation II but p=0.4 and the attention parameter is not p=0.8 but only p=0.6. As mentioned before, Standard Constellation I describes the ideal case, Standard Constellation II should be a fairly realistic reproduction of empirical reality and Standard Constellation III is an example of a relatively unfavorable initial situation. The three configurations are deliberately compared to check whether the parameter effects are more or less robust.

Furthermore, the problem input and problem-solving capacity has to be determined. The problem input is 4 problems/period in all three constellations. The problem-solving capacity is 12 problems/period for Standard Constellation I, 48 problems/period for Standard Constellation II and 100 problems/period for Standard Constellation III. These values are equilibrium values for the relevant configurations, i.e. for the specified problem-solving capacities, *on average*, there are just as many problems that leave the decision system, as being solved as there are those that enter the system. If the problem-solving capacities are lower, more and more unsolved problems accumulate in the decision system, which leads to an unmanageable overload. Increasing the problem-solving capacities beyond the equilibrium point does not make sense; it only leads to over-dimensioning of the decision system. The reason for this is that time and again there are errors in the decision system regardless of the capacities available for the solution (inadequate consideration of problems, errors, obstacles). Thus, there is always a certain number of unsolved problems. The number of problems can only be reduced by addressing the problem more thoroughly or reducing the obstacles or improving the problem-solving capabilities.

Selected Effects

Attention

In the ideal constellation (no obstacles, problems are fully addressed, no errors), all problems will be solved in a timely manner if the problems arising are given due attention.[9] If attention is reduced, the problems that are not addressed and thus not solved will accumulate. However, there is a quasi-natural limit. Even if an emerging problem does not attract attention, sooner or later it will be solved. The explanation is to be found in the model assumptions. According to them, problems cannot be denied in the long run. The longer a problem is ignored, the more severe the consequences of this disregard will be, until finally they can no longer be ignored. The longer the period of disregard lasts, the greater the pressure of attention so that the problems are finally perceived and addressed, albeit with some delay. However, the backlog of problems resulting from addressing the problems with delay cannot be cleared so that there is always a set of unsolved problems to be dealt with.



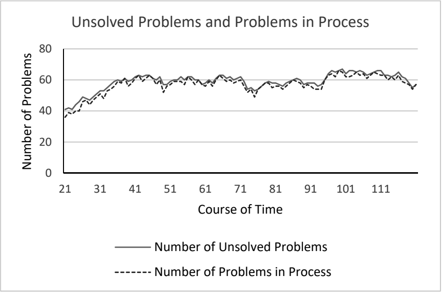


Figure 2: Attention and problem backlog
(standard constellation II, attention, left p=0.2, right p=0.8)

Figure 2 shows two alternative values of the attention parameter. In the first case, where attention is relatively low, a considerable problem backlog is built up. In the second case, where almost every problem of the new problems is identified as a problem, the backlog of problems drops significantly.

Addressing the Problem

Addressing the problem is about the question whether you pay attention to a problem, whether you try to solve the problem *after* you became aware of the problem, whether you seek a solution, whether you implement the solution found. There are many causes and reasons why organizations do not dedicate themselves to these activities. Perhaps they do not attach great importance to the problem, they do not feel responsible or they think that others will take care of the problem. Furthermore, they often hope that the problem will disappear on its own. Maybe they find it difficult to understand the nature of the problem; they wait to see whether it manifests itself over time, they presently do not have the energy to start a problem discussion, they do not have the courage to urge unwilling colleagues to participate, etc.

9 Of course, this only applies if the problem-solving capacity is large enough.

The effects of not addressing the problem can be easily illustrated by the implementation phase. The implementation phase begins in the simulation model with the time when a solution is available (regardless of how good the solution is). If many problems for which solutions have already been worked out are deferred, the problem-solving level will drop considerably. For example, if every second problem is implemented with a delay (parameter value p=0.5), the problem-solving level[10] will only reach 67.7 % and in one third of the cases more than 40 periods are needed until successful completion.[11] If the actors do not initiate implementation in a timely manner, this may lead to a significant increase in the overall process duration, i.e. you will need more time to solve the problem. The reason for this is that you later inevitably have to deal with a problem you did not address immediately. However, this will become increasingly difficult because, in the meantime, other problems will come to the fore and tie up processing capacity. The competition for problem processing ranks is responsible for increasing the problem processing time considerably if problems (for which solutions have already been found) are left untreated, i.e. if you do not start the implementation of the solutions immediately. What is important is not the time effect of the processing delay but the fact that the untackled problems remain in the decision system thus "blocking it up". The time needed to readdress a problem significantly increases because the new incoming problems compete with the existing problems in the system for priority. Since problem capacities are limited, it takes longer and longer for them to advance in the priority sequence until it is their turn and they are addressed. In this respect, there are not only problems with the implementation but also the development of a solution (i.e. the handling phase) and the examination of the problem, i.e. an appropriate problem definition. The model logic deals with the inherent problems in the same way resulting in "empirically" similar patterns for problem definition and problem handling as in the example of the implementation problem.

Obstacles

Each of the decision phases has its own problems. The simulation model highlights three "obstacles" which may occur in one of the decision phases. A particular challenge in the definition of the problem is posed by *conflicting interests* of those involved. Since the problem definition is a key preliminary decision for the further processing of the problem, it is useful for actors to position themselves already in this phase according to their oftenconflicting interests. The resulting disputes may

10 Defined as the share of problems that are successfully implemented within the specified time frame.

11 The selection parameter (or "overlooking" parameter) is identical to the parameter for addressing the problem, its values are the complement for addressing the problem. A value of p=0.6 of the selection parameter corresponds to p=0.4 of the parameter for addressing the problem. If the selection parameter of the problem definition assumes the value of p=0.6, this means that the problem is not defined in the given time period with a probability of p=0.6 but is "deferred", i.e. "rejected".

strongly impair the common problem analysis and the definition of objectives. With regard to the implementation phase, the model focuses on rather *technical and organizational adversities*. It would be illusory to think that the implementation of a decision is only the settlement of a fixed action plan supported by a broad consensus. Unsettled (political) resistance is manifested also and especially in the implementation. However, since the implementation takes place against the background of an authorized decision, it is difficult to raise fundamental objections in the implementation phase. Accordingly, resistance (also in its political dimension) manifests itself primarily in spurious or real deficiencies in the control of the solution approach and in disputes over the right use of resources. In the handling phase, it is above all important to have *rules and procedures* that are suited to facilitate the appropriate development of promising solutions and compromises. Missing and immature institutions and routines hamper the search for and the development of solutions.

The model assigns obstacle parameters to all of the three above-mentioned decision phases.[12] However, there is a special aspect for the handling phase. In this phase, the procedure parameter is not the only parameter used. The other two obstacle parameters also affect problem handling. In terms of content, this model assumption is derived from the fact that the search for solutions is often indefinite both from a mental and material perspective. Therefore the forces, which primarily determine the definition of the problem and therewith the formation of the will and the sphere of concrete action, try to get access to the problem-solving phase too.

Since the obstacle parameters influence the decision process in a similar way as the parameters for addressing the problem (see the previous section), a similar course can be found, i.e. the phase lengths increase first linearly and then exponentially up to an amount of approximately p=0.6 for the obstacle parameters. An increase of the parameter that maps the technical organizational prerequisites, which complicate and thus lengthen the implementation phase also indirectly goes along with an increase in the duration of the definition phase. Since the technical organizational parameter is also important in the handling phase, it also (indirectly) affects the definition phase. The same applies to the interest parameter, which is important in two phases: in the definition phase and in the handling phase. Thus, delays in the handling phase also lengthen not only this phase, but also all phases of the decision process. Obstacles also have effect on the capacities, which are required to keep the decision system in balance. As already described, the increase of the selection rate which refers to the *initiation of implementation* from p=0.0 to p=0.4 requires an increase of the capacity (in the ideal situation) from 12 to 15 problems/period. This increase is not sufficient for the same increase of the selection rate, which refers to

12 At a more general abstraction level, you do not have to commit yourself to conflicts of interest, problematic decision routines and technical or organizational difficulties. You can conceive the variables in the model as general phase-specific obstacles and leave it open what obstacles are behind it.

the *technical organizational obstacles*. Here an increase of the capacity to 18 problems/period is needed to maintain a stable balance. The additional increase is necessary because the technical organizational prerequisites have not only a direct effect on the implementation phase but also an indirect effect on the handling phase.

Capabilities

Capabilities are not sufficient but they are necessary conditions for the development of successful problem solutions. In our model, the result variables react very sensitively to changes of the capability parameter. Of course, the reason for this is the mechanisms inherent in the model. Firstly, it is assumed that each decision system considered is characterized by a separate capability level, which has effect in *all* decision phases. In the simulation model, poor problem analysis skills are associated with poor problem solving and solution implementation skills. Thus, the capability gaps accumulate over all phases of the decision process, which severely impairs the number of decision processes successfully completed in a certain period of time. Secondly, it is assumed, that the decision makers become aware of the quality of the decision only at the very end, i.e. when it becomes apparent, that the decision cannot be implemented. This means for example that it is not noticed, whether the problem analysis is faulty. If one starts with a wrong problem analysis, the process just continues and produces unsuitable solutions and failures in the implementation. Errors may occur in all decision phases. In any case, a significant error – regardless of where it occurs – means that the problem must be readdressed and the entire process must be repeated which drags out the decision process.

Problem Inflow

The standard model envisages a constant problem inflow of 4 problems per time period. Since problems arise at rather irregular intervals in reality, it is of interest how the decision system deals with a problem inflow, which is heavily determined by chance. Figure 3 shows the number of problems circulating in the decision system for the 100 periods considered in relation to the problem inflow. In one case, there are 4 problems entering the decision system per period. In the other case, the problem inflow varies *uniformly* between 1, 2, 3, 4, 5, 6 and 7 problems per period. In both situations, there are 4 problems per period on average. In the random condition, however, there is much more unrest in the system.

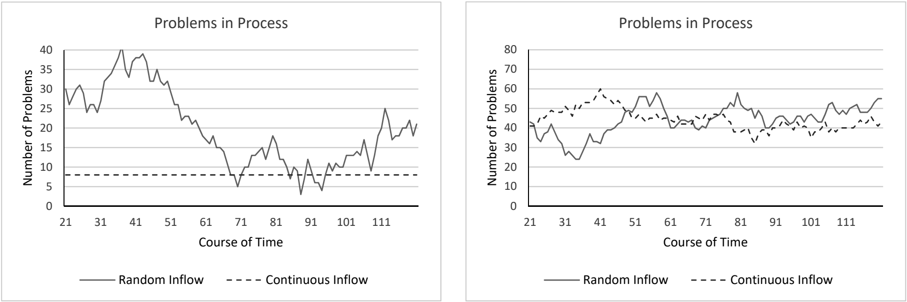


Figure 3: Number of problems depending on the problem flow
(left side: Standard Constellation I, right side: Standard Constellation II)

In the periods in which the number of problems arising exceeds the problem-solving capacity, there is a backlog of problems, which cannot be easily cleared by overcapacities in the other periods. This leads to a longer decision time. It should be noted for these results that averages (from 10 simulation runs for each constellation) of averages (the 400 problem courses) are considered. For the "extreme distribution" condition in Standard Situation I, for example, there are decision times of 15 periods and decision times of only 5 periods (which are, as mentioned before, averages). At the individual problem level, the variations are much greater. In the given constellation (extreme distribution in Standard Situation I), there are individual decisions that take more than 30 periods as well as decision processes that are completed after only 3 periods. With s_p=9.9, the standard deviation at the problem level is significantly higher than the standard deviation at the aggregated level (s_{agg}=2.4). The same applies to the other constellations. The extension of the decision time caused by the irregular problem inflow can only be reduced by an increase of the problem-solving capacities, which are able to absorb a backlog of problems arising from load peaks.[13]

Significance

Significant problems are given priority. As mentioned before, significance increases with time, i.e. if a problem is not addressed, its significance increases successively.[14] This increases the likelihood that it successfully competes against the other virulent problems and is dealt with. It should be obvious that it makes a difference how large the increase in significance is. For instance, if the significance of a problem increases only slowly with each period in which it is not considered, it will take longer

13 This applies at least to Standard Constellation I in which all other conditions are ideal, i.e. cannot be improved. In the other constellations, the improvement of capabilities and addressing the problems makes the process more effective and the reduction of decision obstacles is of course also useful.

14 Significance represents, in a certain sense, an aggregate measure of both importance and urgency.

until the problem is addressed than if the increase in significance is very large. In Standard Constellation I (no errors, no obstacles, problems are fully addressed, proportionality of capacity and problem inflow), the significance is, however, literally "of no significance" because in this situation, problems are "cleared" as quickly as they appear so that there is no competition between them. Of course, this changes if the capacity is not sufficient to meet the incoming problems. *If there is no change in significance over time*, all problems maintain their original significance, regardless of how long a problem has already been in the decision system. As a result, problems of little significance have virtually no chance of ever being dealt with. If capacities are not sufficient to tackle less significant problems besides the more significant problems, they accumulate and wander around in the system without a chance of being solved. In Standard Constellation I, i.e. in the case in which there is neither a lack of attention nor missing capabilities and there are no decision obstacles, an increase of the problem input from 4 to 6 problems per period means that one third of all problems are never dealt with.

This changes if significance is adjusted. If the significance of problems increases with non-consideration, all problems will eventually be dealt with. However, greater significance does not necessarily mean that more problems are solved *in a given time frame*. The model calculation for Standard Constellation II shows that, irrespective of whether the significance is[15] 0.2... 0.4... 0.6... 0.8 or 1.0, in about two thirds of cases more than 40 periods are needed to solve problems (which is caused by the imbalance between problem inflow and problem-solving capacity).[16] However, there will be considerable change in the *extent to which problems are considered*, in particular those problems, which initially were of little significance. This also reduces the number of problems that have to wait long for their processing. This is especially true if problem-solving capacities are undersized.

Interactions

In our model as in reality, events are not only controlled by a single mechanism. Furthermore, the different mechanisms, which are responsible for problem processing, are intertwined in many ways. Accordingly, the correlations described in the previous sections can only be fully explained if the entirety of the assumed effect relationships is considered and if the initial conditions are included in the considerations. This applies not only to the bivariate relationships, which have been reported so far but also to the correlations resulting from the interaction between several variables. The last section already referred to an example of the interaction of problem-solving capacity and increase in significance.

15 For example, if the significance parameter is $g_{p(it)}$ = 0.1, the significance of a problem increases with each period in which it is not considered (there are no definition, problem-solving and implementation activities) by the specified factor f=0.1.

16 These figures result from the analysis of Standard Situation II for a continuous inflow of 4 problems/period.

Figure 4 provides an example of another correlation. It illustrates the influence of problem-solving skills in conjunction with the issue of addressing problems (here: with regard to the implementation) on the problem-solving level and the decision time. The figure shows that the influence of capabilities on the processing time is significantly reduced if decision-makers fail to give full and due consideration to the implementation.

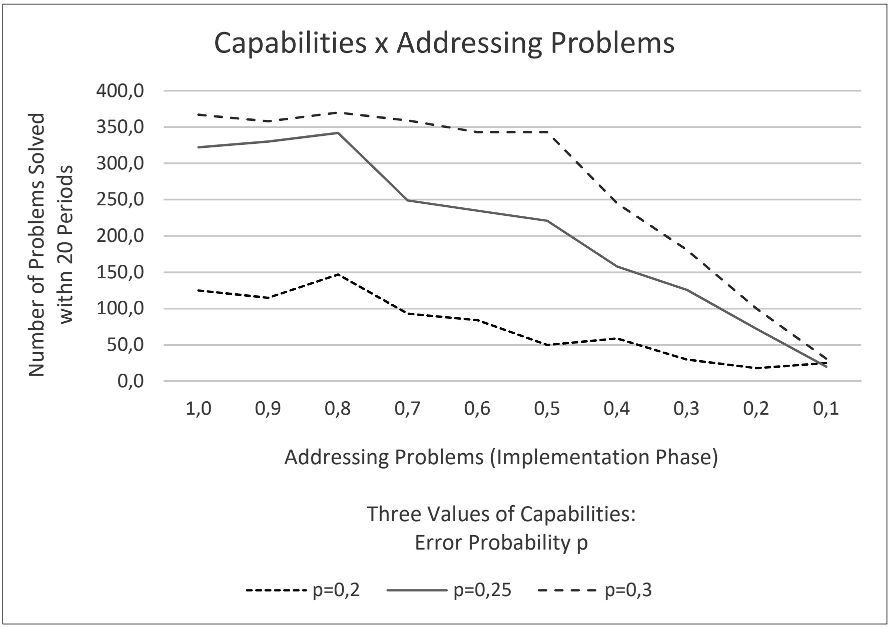


Figure 4: Interaction of capabilities and problem processing on the problem-solving level (Standard Situation II)

The relationship can also be read in reverse: It is definitely worth investing in your own problem-solving skills and this has a positive effect especially when you dedicate yourself to the implementation task. Or, expressed in more neutral terms, capabilities and addressing the problem support each other in the effort to improve decision results (for other examples of interaction effects, see Martin 2019b).

Discussion

The fact that many decision processes in organizations do not produce the results they aim for is not really surprising: The problems are many, decision tasks are numerous, capabilities are poor, chance is omnipresent. The model of addressing problems described in this article deals with this decision situation. The simulation model is focused on the time needed for the various decision activities and the time patterns formed in the decision process (for the latter, see Martin 2019b). Here are some results:

- The capacities needed to keep the decision system in balance significantly exceed the requirements that are calculated when assuming ideal conditions, i.e. assuming that there are no errors, all problems are addressed as soon as they arise and there are no obstacles in the way of the development and implementation of problem solutions. It is an illusion to believe that such a "clinically pure" situation could be created and it is therefore advisable to accept reality as it is and to provide for sufficient capacities even if this does not suit the tendency for cost cutting.
- The need for additional capacities may already increase significantly if the parameter values, which determine problem processing, deteriorate just a little. If this is to be expected, it is advisable to take precautions, to accept "slack" and to allow some "fat" in terms of capacities even if capacities are not always fully utilized.
- Otherwise, it does not make sense to build up overcapacities. This will not solve all problems because there will always be a certain number of unprocessed problems wandering around in the system no matter how large capacities may be.
- The negative effects on the decision time and problem-solving level coming from adverse trends of parameters are almost always non-linear, i.e. they increase disproportionately with increasing deterioration.
- The parameter for addressing a problem does not have lasting effects on attention, because the pressure resulting from the failure to process problems rises continuously over time.
- If two or more parameters change at the same time, the interaction effects exceed the sum of individual effects.
- Obstacles and delays in one of the decision phases almost always have temporal effects on the other decision phases.
- Problems in the subsequent phases cause delays also in "logically" preceding phases, i.e. if problems arise in the implementation phase, for example, the definition phase will also be extended.
- The problems occurring in the subsequent phases have a stronger effect on the overall length of the decision process than the problems in the preceding phases.

Furthermore, it should be noted that decision processes can produce very different results even if the initial constellations under which they start and run are identical. Conversely, very different constellations often produce the same results. If you think about it, this is not surprising but results from the logic of the model, which should come close to empirical reality in this respect.

An important aspect which is not considered in this model is the "disappearance of problems", i.e. the fact that problems disappear without being addressed. There are a number of reasons for this: The persons responsible for the problems no longer insist, system requirements (and thus problem situations) change, problems are solved when dealing with other problem-solving processes (quasi as bycatch) etc. Furthermore, problems are simply forgotten, be it due to negligence or "active omission". The conscious suppression or deferral of problems may be successful because it leads to a temporary relief of the decision system or, as described above, problems eventually disappear. However, forgetting problems can also have negative effects because neglected problems may return with full force at a later point in time. There are many other complications of the decision process, which are not dealt within this model but nothing speaks against including aspects of this problems in our model or subjecting them to a specific analysis in a modified model design.

Other questions refer to the theoretical understanding and the operationalization of constructs and mechanisms. One of them refers to the nature of the "problem construct". Our model assumes that there are objectively identifiable problems. This means that certain conditions and developments will have inescapable negative effect on the functioning of the system under consideration, i.e. in our case, on the functioning of organizations. If no countermeasures are taken which make these problematic conditions and developments manageable, the existence of the decision system or even the organization will be at risk.

One of the frequent arguments against this view is that problems achieve their status only if people regard and define them as problematic. A simulation model, which is based on this view must focus more on the perceptions and behavior of the participants in a decision process. However, it cannot do without simplifications either. A problem which arises for this approach is, for example, to define the group of participants, which might be very difficult because the composition of the group of people involved in a decision often changes significantly in the different decision phases (and from decision episode to decision episode) and with regard to the decision tasks to be performed. On the other hand, elements of the participants' behavior could also be integrated in our selected layout of the simulation model. However, this is hardly possible without theoretical simplifications on the one hand and programmatic complications on the other. But more important is, that such a model extension does not seem essential for our purposes.

As far as the operationalization of concepts is concerned, modeling can also be carried out differently. To give but one example, the importance of problems in our model is determined by the assignment of priority weights. However, it would also be possible to define, for example, classes of problems of different importance. Important problems could be allocated an increased attention affinity or special increase rates in priority setting. The question of which of these operationalization should be preferred is difficult to answer. The model purpose is ultimately the decisive factor.

In terms of content, there needs to be a discussion on how the mechanisms are to be mapped. One example refers to the necessity of resuming a decision process. In this model, the resumption is induced by error probabilities. It would also be possible to make the resumption dependent on the value of a diligence ratio, which may result from the type of decision course. Another example is the linear increase of the pressure due to non-consideration. An exponential increase or the differentiation of the increase by problem importance may be more realistic. Altogether, the described and similar changes and extensions only refer to details. The results, which can be derived from the model analysis are likely to remain unaffected.

As far as the performance of the simulation method is concerned, a point of criticism can be that the results obtained in the simulation calculations are no "real" findings because they are derived from the premises of the model and the logical instructions of the program. So it is hardly surprising with regard to our model that especially the errors that are already made at the beginning of the decision process lengthen the process to a greater extent than the errors that are made at a later point in time. Finally, the model assumes that an error once made is dragged through the entire process and only identified as such at the end so that the intermediate phases are recorded as lost time. The fact that the impairment of capabilities has a great impact is due to the importance that is assigned to the capabilities by the model, because in the model the capabilities (and in reality too) are needed in all decision phases and thus affect the entire decision process, rather than only individual decision phases. Other correlations that are only revealed by concrete model calculations cannot be easily assessed. Making them explicit and tracing behavior lines that are responsible for their creation is a key and worthwhile component of the simulation calculation. One example in this model refers to the surprisingly strong effects of even minor changes of the problem-solving capabilities.[17]

It is not always easy to have an overview of all conclusions of a more comprehensive statement system. This fact is based on the truism that the explanation task is much more difficult than the usual examples in epistemological textbooks, which are oriented towards the Hempel-Oppenheim scheme, suggest. This applies at least to the explanation of the behavior of individual cases. To be able to fully explain the values of a result variable of a specific case, all variables of the model must be considered because, in one way or another, they all affect the process that produces the result. Furthermore, all initial conditions must be considered to provide a "full" explanation and – as decision-making is a dynamic action where random influences apply – all intermediary states of the system must also be considered.

This applies analogously to the other direction where it is not about the explanation but the prognosis: The results are inherent in the assumptions but they are difficult

17 Implausible model results should give reason to think about possibilities to improve the model. As far as our model is concerned, it may be advisable to consider mechanisms, which facilitate the timely detection and correction of errors in organizations.

to predict. It is only possible to achieve improvements in prognosis. The statistical analysis is a great help as far as it allows you to obtain more details about the probability that the event will occur if the relevant initial conditions prevail. However, these prognoses also remain vague because they do not concern the individual case but only the probability of occurrence of event classes.[18]

Ultimately, simulation studies are not concerned with explanations, prognoses or individual statements but with the entirety of the statement system and the question as to what extent it is able to describe the causal structure which can produce the empirical phenomena of interest. The possible acquisition of knowledge results from the confrontation of the model assumptions with the calculation results. The examination thereof is useful and necessary because the conclusions of a fairly complex system of statements are trivial only in a logical sense. The conclusions resulting from the set of assumptions are often surprising, they may contradict conventional views and seem to be implausible at first glance and possibly at second glance, too. But this is what the simulation is about: the development of interrelationships that cannot be easily recognized and, based on this, the adjustment and correction of the model and the underlying theoretical considerations. In this respect, the development of a simulation model is a decision process where again and again problems must be reanalyzed, solutions must be found, operationalization must be tested and errors must be corrected.

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